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Wind turbine power coefficient estimation by soft computing methodologies: Comparative study

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A B S T R A C T

Wind energy has become a large contender of traditional fossil fuel energy, particularly with the successful operation of multi-megawatt sized wind turbines. However, reasonable wind speed is not adequately sustainable everywhere to build an economical wind farm. In wind energy conversion systems, one of the operational problems is the changeability and fluctuation of wind. In most cases, wind speed can vacillate rapidly. Hence, quality of produced energy becomes an important problem in wind energy conversion plants. Several control techniques have been applied to improve the quality of power generated from wind turbines. In this study, the polynomial and radial basis function (RBF) are applied as the kernel function of support vector regression (SVR) to estimate optimal power coefficient value of the wind turbines. Instead of minimizing the observed training error, $SVR_{\_poly}$ and $SVR_{\_rbf}$ attempt to minimize the generalization error bound so as to achieve generalized performance. The experimental results show that an improvement in predictive accuracy and capability of generalization can be achieved by the SVR approach in compare to other soft computing methodologies.

1. Introduction

Due to global environmental pollution emergence, trends towards the sustainable energy and green power sources such as wind energy have risen. Wind energy is one of the economic renewable sources and a feasible alternative to conventional energy sources. The common goal of the wind turbine is to maximize favorableness by maximizing energy extraction, and therefore the power output of the wind turbine often varies with vacillating winds. Until recently there have been no requirements or market motivators for wind turbines to control their power output [1]. Higher wind insight levels have increased the interest for wind turbines to provide additional services that are critical to grid dependability by controlling their power output through power control [2,3]. Development of control solutions is a valuable approach to reduce reduction of operations and maintenance costs of wind turbines [4].

Modern large wind turbines can be classified into three different types, including the constant speed type, variable pitch control type and variable speed type. Variable speed wind turbine power generation system is more superior to others because of its high power extraction efficiency and high power quality [5–7]. In the operating wind speed range, in order to achieve the maximum power point tracking of wind turbine, the turbine shaft rotational speed should be adapted optimally with respect to the variable wind speed [8]. Such turbine rotor speed control should base on the real-time information of wind speed. When the wind speed is lower than the rated wind speed, the rotational speed of the wind turbine is controlled according to the variable wind speed by the rotational speed control of the generator for keeping the optimal power coefficient C_p of the wind turbine. The variable pitch control of the wind turbine blade generates the optimal electric power when the wind speed is higher than the rated wind speed.

The wind systems are nonlinear power sources that need accurate on-line identification on the optimal operating point [9–11].

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